Standard Oil Engineered Materials Company

SCHEDULER CONFIGURATION USERS GUIDE

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The CONFIGURATION disk initially has EIGHT files on it:

File	Purpose
COMMAND.COM	Needed to boot the disk
CROPS.EXE	Main program
CROPS.DAT	Main data file
CONFIG.SYS	Needed to boot the disk
ANSI.SYS	Needed to boot the disk
870358.SN	Record of unit #87-0358
RS232.SET	Needed to run the program
README.DOC	Instructions

The program will automatically record the configuration of all units it reconfigures. The serial number of the unit is used as the file name. Within the record is a listing of all changes made to the unit, as well as the owner's name. This makes the program also serve as a good file management system.

I. Prepare the Scheduler

Make sure the Scheduler and your PC can actually communicate with each other. The easiest way to do this is to transfer data from the Scheduler to the PC using the procedures described in the training manual. This insures that you do not have any hardware problems.

The Scheduler should be connected to COM1 and configured as follows:

Baud rate:	1200
Char. Size:	8
Stop Bits	2
Parity	NONE
Xon/Xoff	Disabled

To prepare the Scheduler to receive a new set of crops:

R&D Models :
. turn the Scheduler off
. turn the Scheduler on
. press PRINT twice
. press CALC
. press the UP arrow

PRODUCTION MODELS :
. turn the Scheduler off
. turn the Scheduler on
. press PRINT and step through the PRINT sequence
. press CALC twice
. press the UP arrow

When the Scheduler is prepared to receive a new crop set the Scheduler screen should say:

Crop Configuration
being received

Please Standby

you are now ready to run the program

II. Prepare the PC

Place the CONFIGURATION disk in the A drive and press ctrl-alt-del simultaneously. This will boot the system onto the A drive.

You will need to enter the date and time.

After the A> prompt appears you may proceed with the following steps :

1. type CROPS (and press ENTER)

2. at the main menu, press any key to continue

3. Press F6 to select a serial number. A list of all serial numbers stored on your disk will be displayed. Enter the serial number of a unit from this list, or a new serial number. For example, enter 87-0358.

4. The list of available crops will be displayed. If the unit you selected in on your data-base, the crops appearing in that unit will flash.

5. Enter the KEY CODE value. This number will appear in brackets for a previously configured unit. For a new unit, you MUST enter a valid KEY CODE. The KEY CODE for each unit is written on a blue dot on the inside of each sensor gun, at the base of the hand-grip where the cord attaches to to the gun (it can be seed without dismantling the gun head). If this dot has disappeared, it is essential that you obtain this number from our files in Solon. THE SCHEDULER WILL NOT WORK RIGHT IF YOU DO NOT USE THE RIGHT KEY CODE !!!!

6. Enter the customer name. After you enter the KEY CODE, all you need to do is type the name

7. Press F2 to clear the program

8. Use the up and down arrows on the keyboard to place the curser on a crop you want. Press F3 to select this crop. The selected crop should start blinking after you move the cursor to a new crop. You may continue to scroll through the crop list and select up to seven crops using the F3 key.

9. Press F5 to select Fahrenheit or Centrigrade as the temperature display.

10. Press F8 to begin the programming process.

11. Press F2 to make sure the PC is configured as follows :

Data Bits	8
Stop Bits	2
Parity	NONE
Baud Rate	1200
Xon/Xoff	Disabled
Comm Port	COM1

If necessary, use keys F2 through F7 to change the PC set-up

12. Press F9 to return to the configuration menu.

13. Press F3 and wait. When the configuration is done, the screen will say "Transmission Complete". The Scheduler will return to the main menu. If this does not occur within 1 minute, then press F9 to start over (press F3 again, after pressing F9).

14. Press F10 to end the program.

NICHE

SOFTWARE

SCHEDULER COMPANION SOFTWARE

System Requirements: IBM compatible PC, 640K memory, hard disk and DOS 2.1 or higher.

IMPORT

* Data is imported into the program directly from the Scheduler via the COM1 RS-232 port. Or imported from an ASCII file containing Scheduler "Print" formatted data.

* No limit to amount of data stored, other than realizing that the more data kept on the hard disk the longer it takes to search the data for specific samples.

MANAGEMENT

* Sample location identifiers are assigned to the Scheduler location numbers tagging the data with complete identifiers. Up to 10 groups of location identifiers can be utilized, each group containing alpha-numeric names: 240/group for the R&D model and 30/group for the Production model.

* Water data (date and amount) is stored, plotted, and listed.

* Pesticide data (date, material, amount, and units) is stored, plotted, and listed.

* Selected field data can be closed out (removed from the data base).

ANALYSIS

* 120-day stress index plots that include water and pesticide application dates. Plots to screen or printer with a threshold reference line.

* Complete data listings for selected fields and date ranges.

UTILITIES

* Backup and Restore for data protection.

* Export selected data to an ASCII file.

* Set index tables.

SCHEDULER^{R} PLANT STRESS MONITOR PERIPHERAL INFORMATION

1.0 FILE TRANSFER FROM THE SCHEDULER^{R} TO A PC

To transfer information from the SCHEDULER^{R} to a PC, connect the printer cable to the SCHEDULER^{R} and the PC serial port. Then type the following commands on the PC:

```
MODE COM1:12,N,8,2
COPY COM1  Filename
```

On the SCHEDULER^{R} execute the following:

1) Power-up the unit
2) Press the PRINT key
3) Using the ENTER, UP-ARROW, DOWN-ARROW keys, set the following parameters:

BAUD RATE	1200
CHAR. SIZE	8
STOP BITS	2
PARITY	NONE
XON/XOFF	DISABLED
SUN_LOW	either DISABLED OR ENABLED

4) If the historical data is desired press the CALC key, or if the current day data is desired press the ENTER key.
5) Press the PRINT key to start the data transfer to the PC.

At this point any SCHEDULER^{R} data that would have printed to the printer will now print into the file on the PC. The file format is the same as the format that prints when connected to the printer. To print the data file type the following command on the PC:

```
PRINT    Filename
```

2.0 GENERAL COMMUNICATIONS DEVICE DESCRIPTION

Two types of RS232 communications equipment exist:

Type	Examples
DTE - Data Terminal Equipment	Printers, terminals
DCE - Data Computer Equipment	Computers

The difference between the two types of communication equipment is the location of the various signals. For DCE equipment the following applies:

Signal Name	Usage	25 Pin D-Shell Connector Pin
Transmit	Output	3
Receive	Input	2
DCD (Carrier Detect)	Input	8
DTR (Data Terminal Ready)	Output	20

For DTE equipment the following interpretation applies:

Signal Name	Usage	25 Pin D-Shell Connector Pin
Transmit	Output	2
Receive	Input	3
DCD (Carrier Detect)	Input	20
DTR (Data Terminal Ready)	Output	8

The SCHEDULER^{R} Plant Stress Monitor is configured to be a DCE device when the factory supplied cable is used (see Figure 1).

3.0 SCHEDULER^{R} CONNECTIONS TO PRINTERS

To be compatible with the SCHEDULER^{R} Plant Stress Monitor, the DCD signal must always be used to indicate if the connected device is BUSY or READY. Likewise, the Plant Stress Monitor uses its DTR signal to indicate when it is BUSY or READY to accept data.

A "READY" is indicated by a SPACE (+3 to +25 Volts on the cable).

A "BUSY" is indicated by a MARK (-3 to -25 Volts on the cable).

If the device being connected does not adhere to the above definition and is still to be used with the SCHEDULER^{R} Plant Stress Monitor, then a cable must be made which will cause the Plant Stress Monitor to think the device is compatible (i.e. the above defined voltages must be "forced" onto the defined pins on the cable).

3.1 SCHEDULER^{R} TO A SERIAL PRINTER

If a DTE device is to connect to a DCE device (such as the Epson FX-85 printer) then the connecting cable is a straight through cable -- i.e. all pins on one side of the cable connect to their corresponding pins on the other side of the cable.

If a DTE device is to connect to another DTE device or a DCE device is to connect to another DCE device then pins 2 and 3 and pins 8 and 20 must be crossed -- i.e. the cable must be configured as follows:

Pin 2 connects to Pin 3
Pin 3 connects to Pin 2
Pin 8 connects to Pin 20
Pin 20 connects to Pin 8

NOTE: If the PC is an AT style machine, the serial port MAY be a 9 pin male. In this case a 25 pin to 9 pin "pigtail" cable will be needed to plug into the PC serial port and the printer cable.

3.2 SCHEDULER^{R} TO A PARALLEL PRINTER

If the printer to be used has a parallel interface, the following two options are recommended for transferring data to the printer:

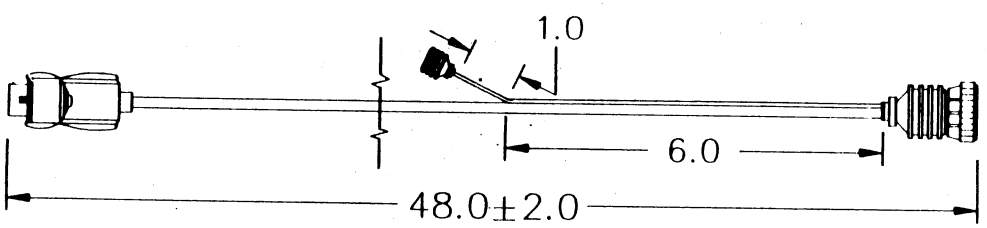
A) Transfer the information to the PC using the information outlined in the section below (File Transfer from the SCHEDULER^{R} to a PC). Then print the data file using the PRINT command on the PC,

B) Purchase a serial to parallel data converter:

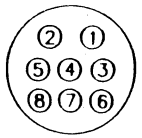
SUGGESTED VENDOR

Applied Creative Technologies
Dallas, Texas
(214) 358-4800
Product Name: Harmonizer
Part No: 02-07-101
List Price: $95.20

DIMS. IN INCHES



PIN CONTACTS



WIRING SCHEDULE

SIGNAL DESCRIPTION	SIGNAL NAME	8 PIN CIRC. CONN.	COLOR	MALE DB25	CABLE PORT
CASE GROUND	RS_GND	5	BLUE	1	NC
DATA INTO COMPUTER	RS_RXD ←	3	BRN	2	NC
DATA FROM COMPUTER	RS_TXD →	6	GREEN	3	NC
SIGNAL GROUND	RS_GND	5	BLUE	7	NC
DTR OUT OF COMPUTER	RS_DTR →	7	ORN	8,6	NC
RING INTO COMPUTER	RS_RI ←	8		NC	
CARRIER INTO COMP.	RS_CD ←	1	YEL	20	NC
BAT. +	BAT. +	2	RED	NC	
BAT. GND.	BAT. GND.	4	BLK	NC	

JUMPER 6&8 ON DB25

PRINTER CABLE

figure -1-

THE SCHEDULER^R -- A NEW TOOL FOR SCHEDULING IRRIGATION AND PLANT STRESS MONITORING

Bronson Gardner*

Irrigation has traditionally been scheduled according to factors that do not include plant measurements. Since the early 1970's, the USDA, as well as several universities have been developing a crop water stress index (CWSI). This index is based on the principle that a surface which is evaporating water is cooler (under the same ambient conditions) than a similar non-evaporating surface. Hence, the rate of water evaporation from a leaf surface modifies plant temperatures. Thus, it is possible to define an index which directly responds to the transpiration rate of a leaf. This index also serves as an indicator of plant stress status.

The Stress Index

The stress index in the Scheduler^R is:

$$\text{Index} = 10^* \left(\frac{Tc - Ta - Min}{Max - Min}\right) = 1 - \frac{ET}{ET_p} \qquad \text{Eq. (1)}$$

ET is the actual transpiration rate.

ET_p is the potential transpiration rate.

Min is the minimum temperature a rapidly transpiring plant can achieve under a given set of environmental conditions.

Max is the temperature a maximally stressed plant can achieve under a given set of environmental conditions.

Max and min are computed from proprietary algorithms. The theoretical range of the index is 0-10 for a given crop. In practice, observed values range between -3 and +13.

In order to compute the index, it is best to simultaneously measure four parameters: canopy temperature, ambient air temperature, relative humidity and solar radiation.

The Scheduler^R can measure each parameter 4 times per second. Up to 55 samples can be collected per data "burst". A burst of 55 samples requires 12-15 seconds to collect the data, with an additional 2-3 minutes calculating time. Up to 18 "bursts" can be included in a set of field averages.

Several software options are available (Table 1).

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How to Interpret the Stress Index

Several interpretive techniques are being used with the Scheduler^R stress index:

Technique 1 -- Threshold Values: With this technique, a user measures the stress index of a crop with the Scheduler^R whenever it is convenient. If the index exceeds a threshold value (usually some constant value the user determines), then the user concludes that stress has begun. As long as a crop canopy stays relatively unchanged between irrigation cycles and the crop does not undergo any radical physiological change, such as rapid leaf expansion, this approach works well. This approach requires some modification if used during a period of rapid crop development, since the relative influence of soil (ground cover) and crop structure on indicated temperatures may change the normal index reading. For example, higher index readings on young healthy cotton than on mature healthy cotton would be normal.

Technique 2 -- Relative Values: With this technique, a user does not consider the past behavior of the index or its absolute value. He is interested in relative differences between areas. As long as a user has an area which he can use as a healthy reference with a high degree of confidence, this approach is very satisfactory. Index differences of 2-3 between an area and a healthy reference area usually indicate the need for irrigation. This approach works well on large operations where it is generally easy to find a recently irrigated area.

Technique 3 -- Seasonal Trends: This technique presumes that a user has a data base for his crop. By examining seasonal graphs of the normal index readings for his crop as a function of crop growth stage, a user can determine if the index readings he is obtaining are within or outside the range of normally expected values. This approach allows for the tailoring of crop stress management to suit specific agronomic objectives such as increasing sugar content in grapes.

Technique 4 -- Cumulative Index Values: Another approach is to take Scheduler^R readings on a systematic basis, such as daily, every second day, etc. When data is collected in this manner, it is possible to begin summing the stress index readings. This approach is similar to the growing degree day approach, except that plant stress readings are substituted for air temperature readings. Studies have shown that cumulative values are strongly related to the total amount of water used. This makes it possible to schedule irrigations on crops where any stress must be avoided, but where over-irrigation must also be avoided, such as celery.

In addition to cumulative stress index values, it is also possible to cumulate VPD (vapor pressure deficit) values. Cumulative VPD values are a measure of how much drying power a crop has been exposed to , serving as an indicator of disease possibilities. VPD values for cumulative purposes can be collected whenever the user feels it is most appropriate. Currently, the calibration of all cumulative values is conducted by the user.

Scheduler^{R} Research

The technology on which the Scheduler^{R} is based began as far back as 1842. Since that time, the ability of researchers to measure plant temperatures has progressed from cumbersome thermocouple systems requiring ice baths to battery powered hand-held infrared thermometers. A large volume of information now exists which shows that moisture stress causes elevated plant temperatures relative to healthy plants.

Since the early 1970's, the USDA has been developing procedures which quantify the systematic relationship of leaf temperatures to environmental parameters such as relative humidity, air temperature and solar radiation. Many different universities have joined in that effort.

In 1984, Standard Oil began developing a commercial version of this technology. Nationwide testing was conducted on corn in 1985 using a prototype model. This test showed that the technology could be made in a form acceptable to growers and that the cost/benefit ratio could justify its purchase.

A second model was built in 1986 which incorporated the lessons of 1985. These models were made commercially available and were also installed on a number of research projects. Although many crops had been researched by others using stress index theory, the decision was made to validate existing baselines and develop new baselines for crops that had not been researched. This effort resulted in an extensive data base and the discovery of calculation procedures which enhanced the stability of the index in cool and humid regions. Research is continuing on improved calculation procedures.

The lessons of 1984-1986 were incorporated into the 1987 model, resulting in a technically accurate, easy to use instrument which provides a great deal of information about plant stress status.

Table 1. Scheduler^{R} Software Features

General

- Easy to use. Only eight buttons to push (ON/OFF, HELP, PRINT, DEL, ENTER, UP, CALC, DOWN). No computer experience needed.
- Seven pre-programmed crops per unit.
- RS-232 compatible for down-loading to external computers and printers.
- Easily replaced EPROM's for changing between software programs. (Currently this change is made for the user only by our technicians).
- Modem communication for easily changing crops and their associated baselines.
- Real-time clock.
- Battery test feature.
- Visual display of the difference between crop and air temperatures.
- Sunlight level feature to automatically delete any data collected at less than 65% full sunlight. The user can enable or disable this feature at will.

Production Software

- 15 day data storage for stress index values for each of 30 separate fields or locations.
- Graphical display of the stress index trends for the most recent 15 days for each of 30 fields. This allows rapid in-field decisions without using an external computer.
- One-day storage of mean values of crop, temperature, air temperature, relative humidity, solar radiation and the stress index. Also stores the time, date and number of samples associated with each average. Means are automatically deleted at mid-night.

R & D Software Features

- One day data storage for average values of crop temperature, air temperature, relative humidity, solar radiation and the stress index for 240 separate fields. Standard deviation of crop temperature, vapor pressure deficit, date, time, field number, crop name, and number of samples collected with each average. No data is deleted automatically.
- Ability to transmit all data in real-time to an external RS-232 device, making it possible to capture all the data observed by the Scheduler^{R}.
- Switchable between ^{o}C and ^{o}F.

Additional software applications programs are being developed.

Table 2. Scheduler^{R} Hardware Features

- Aspirated air temperature and humidity sensors.
- Infrared thermometer
  - Distance: one inch to infinity
  - Range: $\pm$ 60°C from ambient
  - Field of view: 6°
  - Spectral response: 8-14 um
  - Accuracy: $\pm$ 0.5°C
  - Repeatability: $\pm$ 0.1°C
  - Emissivity: 0.99
  - Operating distance: 1 inch to infinity
- Ambient temperature
  - Range: 0°C to 60°C
  - Accuracy: $\pm$ 0.5°C
  - Resolution: 0.1°C
- Humidity
  - Range: 0 to 100%
  - Accuracy: $\pm$ 5%
- Solar Radiation:
  - Range: 0 to 100 mW/cm^2
  - Accuracy: $\pm$ 10%
- Response Time:
  - Screen update < 2.0 seconds
  - Sample frequency < 0.5 seconds
- Microprocessor: 64-K -- 8 bit.
- Display: 2-1/2 X 1-1/2 LCD on processor
  - 1-1/2 X 1 inch on sensor gun
- Serial Interface:
  - RS-232 25 pin male connection
  - Band Rates: 50-2400 (selectable)
  - Character Sizes: 5-8 (selectable)
  - Other download parameters also selectable
- Softside carry case.
- Warranty: 1 year
- Power -- 6 C cell batteries, with an expected life of 20 operating hours.
- Recharging port provided for use with rechargeable batteries.

Table 3. Selected Institutions Where Scheduler^{R} Research Was Conducted In 1986 And The Results Obtained.

Institution	Crop	Data Obtained Showing the Scheduler^{R} Indices are Related to:
Texas A & M	Turf	Water use, plant health
Univ. of Florida	Turf	Soil water content
USDA, Colorado	Soybeans	Water use, yields, photosynthesis
USDA, Colorado	Corn	Water use, yields, photosynthesis
Univ. of Nebraska	Corn, Wheat, Soybeans	Baseline confirmation
Oregon State Univ.	Potatoes	Water use, soil water, yield quality
Fresno State Univ.	Grapes	Water use, stomatal resistance, yield quality, disease
Fresno State Univ.	Green Beans	Water use, yields
Fresno State Univ.	Watermelons	Water use, yields
USDA, Arizona	Alfalfa	Water use, yields
Univ. of Calif.	Cotton	Leaf water potential, yields

In addition, we obtained data from independent researchers and the USDA on the following crops: pecans, jojoba, nectarines, almonds, tomatoes, cucumbers, celery, wheat, sugar beets, and several others. Extensive research is also being conducted in 1987 on several crops.

Table 4. Applications For The Scheduler^{R} Plant Stress Monitor

The Scheduler^{R} provides data for a wide range of research applications.

- Scheduling irrigation in many crops.
- Scheduling PIX applications in cotton (effectiveness decreases with increasing stress)
- Scheduling STAM applications in rice.
- Controlling bunch-rot in grapes.
- Scheduling Round-up applications on weeds (the higher the stress, the lower the kill rate).
- Measuring soil temperatures before transplanting sensitive seedlings.
- Locating "hot spots" caused by disease, insects, compaction, plugged irrigation emitters, etc.
- Quantifying the effects of too much rain or too much irrigation. Oxygen depletion commonly causes plant stress in saturated soils.
- Estimating daily evapotranspiration values.
- Quantifying the minimum temperatures plant experience at night.
- Monitoring plant temperatures during periods of concern about frost.
- Measuring fruit temperatures in grapes and other crops.
- Measuring the temperature of vital plant parts, such as stem temperatures in grapes.
- Controlling humidity levels in vineyards.
- Insuring no stress is experienced by potatoes, watermelons, and other crops which are highly sensitive to stress, without over-irrigating.
- Generally reducing the amounts of over-irrigation.
- Controlling leaf temperatures in greenhouses. Some plants require daily cycles in vegetation temperature for optimum response. Others require constant vegetation temperatures for best response.
- Quantifying the effect of chemical applications on plants. Herbicides, insecticides and fungicides affect plants to varying degrees.

Table 4 Continued

- Quantifying the uniformity of plant behavior in the field, greenhouse or nursery.
- Quantifying the drying power of the air, to relate to disease factors.
- Estimating yield reductions due to stress.
- Controlling plant responses and fruit quality by careful management of stress levels.

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PRODUCT FEATURES

Scheduler[R] Plant Stress Monitor

- Four sensors (Infrared Thermometer, Air Temperature, Relative Humidity and Sunlight Intensity)
- Aspirated Air Temperature and Relative Humidity
- Digital Temperature compensation for the IRT
- Serial Port for Downloading ASCII Files
- Real-Time Downloading to an External PC
- Large Memory
- 240 Separate Lines of Data
- Each Data Line Represents up to 999 Individual Samples
- Means of Sample for Each Sensor
- CWSI Calculated and Stored for Each Data Line
- Standard Deviation of IRT Readings Stored
- Date, Time and Location Stored

Support Software:
- Downloading the Scheduler to a PC
- ASCII Data File Storage
- Graphing for Preliminary Analysis

Croplink[TM] Crop Monitoring System

Field Station:
- Five Standard Sensors (Infrared Thermometer, Relative Humidity, Air Temperature, Wind, Sunlight Intensity)
- Eleven Separate Input Channels (Voltage, Current or A.C. Resistance)
- Battery Operated (Solar Panel Included)
- Can be Installed on Any Rigid Location (Poles, Trees, Pipes, etc.)
- Pulse Accumulator and Status Bit Channels Also Standard
- Additional Channels (Current or Voltage) are Optional

Base Station:
- One Mile, Line-of-Sight, Infrared Telemetry
- Up to 100 Separate Field Stations can be Linked Together by Using Repeaters (optional)
- No Radio Frequency License Required
- No Radio Interference Generated
- No Long, Expensive Wires to Install or Maintain

Software:
- Data-Logging at Several Optional Intervals on Any DOS Compatible PC (Serial Port Required)
- User Defined Data Storage Options for Each Sensor at each Field Station:

Reports

Minimum/Maximum	Daily Values	Sensor Specific
Cumulative Values	CWSI/ETp Calculations	
Hourly, Weekly, Monthly, Yearly		

Weatheredge[TM] Infrared Thermometer

- Accuracy +/- 1° C, 0.2° C Repeatability
- Input Voltage 5.2-30 V.D.C.
- Linear Output 0-5 Volt or 0-20 MA
- 30 MA Operating Current
- -10 to 50° C Operating Temperature
- Range -25 to 100° C
- Operates at 95% Relative Humidity in a Non-Condensing Environment

SCHEDULER^{R} PLANT STRESS MONITOR

Production Model

Measurement: Simultaneous measurement of crop temperature, air temperature, relative humidity and incoming radiation. Continuous display of the crop/air temperature differential. Display of the stress index after each sample.

Scale Range: -30° C to 100° C

Operating Distance: 1 inch to infinity

Target Spot Size: 6° FOV

Response Time: Screen update <2.0 seconds
Sample frequency <0.5 seconds

Accuracy: +/- 0.5° C between 0 and 60° C, otherwise +/- 1° C

Repeatability: +/- 0.1° C

Spectral Response: 8-14 microns

Emmissivity: .99

Power Source: 6 size C alkaline batteries
Optional: NiCad batteries may be used

Warranty: 1 year

Microprocessor based (64K)

Display: 2 1/2 x 1 1/2 inches graphics LCD display on processor
1 1/2 x 1 inch bargraph LCD display on sensor gun

Serial Interface: RS232 25 pin male connection
Baud rates: 50-2400
User-selectable communications parameters

Softside Carry Case

Selectable Display in °C or °F

Relative Humidity Accuracy: +/- 5%

Ambient Air Temperature: +/- 0.5° C, resolution 0.1° C

Incoming Solar Radiation: +/- 10%

Display and Memory: 30 field locations, automatic averaging of parameters, graphical display and storage of the stress index for a 15 day period for each memory location.

Number of Crops: Up to 7 user selected crops. Any crop can be assigned to any field by the user. Reprogramming of the crop mix is available.